

## REMARKS

### I. PENDING CLAIMS AND SUPPORT FOR AMENDMENTS

Upon entry of this amendment, claims 1-18 will be pending in this application. Claims 14-18 have been withdrawn by the Examiner as directed to a non-elected invention.

Applicants have amended claim 1 to clarify that the “changes therein” terminology referred to temperature or pressure or both. Contrary to the Examiner’s assertions, this is not redundant. Control can occur based on the scalar values of temperature or pressure, or both, or in response to changes in these scalar values. For example, a control system can cause an action to occur when the temperature or pressure reach certain set points; a different control system might cause an action to occur when the temperature or pressure has increased or decreased by a particular amount. These are two different mechanisms for control, since the input variable to the control scheme is different.

Applicants have also amended claim 1 to clarify that their process is continuous, and to incorporate the specific control mechanisms recited in claims 3-5, which have consequently been canceled.

No new matter has been added.

Applicants affirm the election of Group I, claims 1-13.

### II. INDEFINITENESS REJECTION

At page 5 of the Office action, the Examiner has rejected claims 1-13 under 35 U.S.C. § 112, second paragraph, as indefinite. Applicants respectfully traverse this rejection and request reconsideration and withdrawal thereof.

The Examiner has alleged that the terminology “changes therein” in claim 1 is ambiguous. Applicants have amended claim 1 to eliminate this terminology.

Accordingly, the rejection is moot.

### III. REJECTIONS OVER ANDERSEN ET AL.

At pages 4-5 of the Office action, the Examiner has rejected claims 1-13 as anticipated under 35 U.S.C. § 102(e) or obvious under 35 U.S.C. § 103(a) over Andersen et al. (U.S. Patent No. 6,506,360). Applicants respectfully traverse these rejections and request reconsideration and withdrawal thereof.

The process of this invention relates to a method for controlling a reaction by monitoring temperature and/or pressure in the reaction vessel, monitoring the surface area of a solid material inducing the reaction that is in contact with one or more reactants, and controlling the contact area in response to information obtained from the monitoring step. This allows for the control of a continuous, semi-batch, or batch process in a safe and effective manner. Applied to dissociation of hydrogen from water, the control method of the invention allows for the safe, continuous production of hydrogen on demand, allowing water to be converted to hydrogen as needed to power fuel cells, hydrogen burning engines, and the like.

In stark contrast, Andersen et al. is limited to a device for converting water to hydrogen in a batch device. While the reaction disclosed in Andersen et al. may superficially resemble that disclosed in Applicants’ specification, in reality either the reactions are fundamentally different, or Andersen et al. misstate what their reaction is and how it works. Either way, Andersen et al. fails to teach or suggest Applicant’s method.

For example, at column 1, lines 13-19, Andersen et al. state:

It is also known that the reaction between aluminum and water is not sustainable at ambient temperature due to the protective oxide layer forming on the metal surface. Therefore, the use of aluminum as a fuel to generate heat and hydrogen gas requires that the protective layer be efficiently and continuously removed, and that the reaction be kept at an elevated temperature.

While it is correct that aluminum oxide should be removed from the surface during reaction, it is not the case that this must be done at elevated temperature.

At column 3, lines 54-62, Andersen et al. state:

The preferred catalyst form is sodium hydroxide (NaOH) in various forms. . . . The catalyst is not chemically consumed in the process.

Later, at column 5, lines 63-65, Andersen et al. make the contradictory statement:

After analyzing these data, it was decided that recovery of the solid residue was unnecessary since it must be alumina ( $\text{Al}_2\text{O}_3$ ), *or some form of alumina-sodium hydroxide complex*. This could be reclaimed and reprocessed into refractory products or recycled into aluminum. [Emphasis added].

If sodium hydroxide is catalytic and is not chemically consumed in the process, then how does it form a complex with alumina sufficient that the entire complex precipitates and can be recovered and recycled?

These statements, if taken as correct, indicate that the Andersen et al. process is fundamentally different from that disclosed in Applicants' specification.

Alternatively, the statements indicate that Andersen et al. were, at best, unclear about exactly what reaction they were describing. Either way, one of ordinary skill in the art would not have been motivated to modify the Andersen et al. process in any way,

in light of the lack of understanding evidenced in Andersen et al. as to how the process worked.

In addition to these distinctions, the control process used by Andersen et al. is rather primitive and limited in applicability to a simple batch process. It is completely unsuitable for control of a continuous, on-demand process for producing hydrogen gas. While pressure inside the device may be used to control reaction rate in the sense that catalytic material is raised out of, or immersed in, the quantity of batch water in the reactor, this is not how Applicants' claims function. In Applicants' claims, the reaction-promoting material is not moved relative to the level of aqueous liquid; instead, the level of aqueous liquid is controlled relative to the stationary reaction-promoting material. This has several significant advantages as compared to the control scheme disclosed in Andersen et al.

First, Applicants' control method varies the level of aqueous liquid by varying the volume of liquid in the reaction vessel in response to the pressure and/or temperature in the vessel. Andersen et al. does not vary the volume of water in his reactor, but merely moves the catalyst relative to the surface of the water. Applicants' method provides increased safety, since in the event of a pressure increase, less water is present in the reaction vessel to react than is the case in Andersen et al.

An example will serve to illustrate these distinctions. If the Anderson et al. mechanism for lifting the catalyst out of the water were to somehow fail, the catalyst would plunge back into the water, hydrogen pressure would increase, and failure of the reactor vessel, perhaps catastrophically, would potentially result. A similar effect could occur if the vessel of Andersen et al. were upended or overturned: a large

portion of the surface area of the catalyst would then come into contact with water, with no mechanism for controlling the reaction (either because the mechanism had failed, or because it was unable to lift the catalyst out of the water due to the orientation of the device).

By contrast, Applicants' device does not rely on merely moving the reaction-promoting material relative to the level of aqueous liquid in the reactor. Instead, Applicants' control mechanism removes water from the reaction vessel, thereby decreasing the area of contact. If Applicants' vessel were to overturn, the increase in pressure would cause liquid to be forced from the vessel, or would stop liquid from being introduced into the vessel, allowing the liquid level to drop, and providing effective pressure relief and reaction control that is not obtainable with the Andersen et al. method. Similarly, in the event of an overpressure in the vessel, the volume of liquid in the vessel will decrease, providing less reactant to the process and allowing the level of aqueous solution to decrease with reaction of the remaining solution, rather than simply allow the same quantity of solution to remain in the reactor.

Second, Applicants' control methods lend themselves to continuous, on-demand operation. As the Examiner is no doubt aware, continuous process control is quite different, and considerably more complex than batch process control, but also can be significantly safer, as described above. The control methods described in Andersen et al. are not suitable for continuous operation, with the result that the Andersen et al. process is subject to all of the disadvantages of batch operation.

The claimed invention is capable of providing a continuous flow of hydrogen gas, i.e., specific volumetric flow rates, at different pressures for different applications

using thermo-chemical reactions that are exothermic in nature, and are capable of rapidly accelerating to an uncontrolled condition. The control methods of the claims are capable of preventing this rapid acceleration during continuous operation. The control method in Andersen et al. is not. The Andersen et al. control method is suitable only for a batch process on a small scale, capable of producing only modest amounts of hydrogen on an inconsistent basis.

Because the Andersen et al. disclosure does not control a reaction using the techniques recited in Applicants' claims, it does not anticipate the claims.

Because the Andersen et al. disclosure does not motivate one of ordinary skill in this art to modify the control methods disclosed in Andersen et al. to obtain the control methods recited in Applicants' claims, the Examiner has failed to establish a prima facie case of obviousness.

Both rejections should therefore be withdrawn.

## CONCLUSION

Applicants respectfully submit that the claims are in condition for immediate allowance, and an early notification thereof is earnestly solicited. If the Examiner has any questions or believes that any issues remain unresolved, he is respectfully requested to contact the undersigned prior to issuance of a final office action, in order to resolve such issues and speed the application to allowance.

The Commissioner is hereby authorized to charge any deficiencies or credit any overpayment to Deposit Order Account No. 11-0855.

Respectfully submitted,



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